APPENDIX B to
Doc MSSAC 42.7 (Rev. 5)
Doc. IWG2-0 (Rev. 3)
7 April 1993

DOCUMENT LIST OF INFORMAL WORKING GROUP 2 (INTERSERVICE FREQUENCY SHARING) OF THE MSS ABOVE 1 GHz NEGOTIATED RULEMAKING COMMITTEE

Doc. No.	Date	Submitted by	Subject or Title (no. pages)
IWG2-0	2/23/93 (Rev. 2)		List of IWG2 documents (3)
IWG2-1	2/16/93 (Rev. 3)		Roster of participants (5)
IWG2-2	1/15/93	T. Tycz	Excerpts from the Radio Regulations as amended by WARC-92 (4)
IWG2-3	1/7/93	INMARSAT	CCIR Doc. 8D/124 = Sharing of MSS Systems & ARNS Systems in the 1.6 MHz Band (5)
IWG2-4	1/15/93	AMSC	List of Frequency Sharing Problems Between Domestic MSS/RDSS and Other Services and Associated Studies that Should Be Conducted (2)
IWG2-5	1/15/93	R.A. Wiedeman, LQSS	Response to CORF on potential LQSS interference to Radio Astronomy (1)
IWG2-6	1/15/93	R.J. Elandson, Rockwell	Key Inter-Service Sharing Issues (2)
IWG2-7	1/15/93	Motorola	"IRIDIUM L-band Sharing" (14)
IWG2-8	1/12/93	J.L. Nelson, Motorola Satellite Commun.	"Beacon Actuated Protection Zone for Shielding Electro-magnetic Sensitive Sites" (5)
IWG2-9	1/15/93	Comsat/Rockwell	"Excerpts from INMARSAT-C System Design Manual, Out-of-Band Emissions and Immunity (34)
IWG2-10	1/16/93	M.W. Mitchell	"Highlights of First Working Meeting of IWG2 1/15/93 (5)
IWG2-11	1/26/93	C. Windett, LQSS	"Sharing Between MSS/RDSS and Other Services" (15)
IWG2-12	1/25/93	R.G. Gould, Telecom-munications Systems	"A Contribution . . . on behalf of the Radio Astronomy Service (5)
IWG2-13	1/26/93	TRW	"The Resolution of Potential Interference in the Downlink Frequency Band 4990-5000 MHz (4)

IWG2-14	1/26/93	R. Lepkowski, Constellation Communications	"IWG2 Sharing Scenarios" (1)
IWG2-14a	2/8/93	W. Borman, Motorola Satellite Commun.	"IWG2 Sharing Scenarios" (1)
IWG2-15	1/25/93	J. Knudsen, Motorola Satellite Commun.	"Identification of Existing Usage of the Frequency Band 2483.5-2500 MHz" (17)
IWG2-16	1/26/93	J. Binckes, Comsat	"COMSAT/3S Navigation GLONASS Interference Study (1)
IWG2-17	1/26/93	M. Ward, AMSC	"AMSC Intersystem Interference Analysis (5)
IWG2-18	12/18/92	= MSSAC-25	= Doc USSG 7D-2 (USA), "Levels of Spurious Emissions from Spacecraft Harmful to Radioastronomy" and Recommendation No. 66 (Rev. WARC-92) "Studies of the Maximum Levels of Spurious Emissions" (7)
IWG2-19	undated	= MSSAC-26	"Comments of the Committee on Radio Frequencies of the National Academy of Sciences in ET Docket No. 92-28 (Allocation of the 1610-1626.5 MHz and 2483.5-2500 MHz bands for use by the MSS, including non GSO satellites) (5)
IWG2-20	undated	= MSSAC-27	RTCA paper no. 518-91/SC159-317 "Global Satellite Navigation System GLONASS - Interface Control Document (Second Wording) (49)
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IWG2-35a	2/16/93	J. Knudsen, Motorola	Viewgraphs for IWG2-35 (7)
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IWG2-39	2/15/93	E. Reinhart, Coordinator IWG2	Letter to Thomas Tycz re accessing the FCC data base for characteristics and location of U.W. terrestrial stations in and near the 2483.5-2500 MHz band (1)
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IWG2-41	2/25/93	P. Malet, Steptoe et al.	Highlights of Fourth Meeting of IWG2 (2/16/93)
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IWG2-45	2/18/93	W. Vivian, Vivian Assoc for Wireless Cable Assn	**2483.5-2500 MHz Downlink Emissions from Low-Orbit Geosatellites into Adjacent 2500-2686 MHz MMDS/ITFS-/OFS Bands . . . (3)**
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IWG2-47	2/25/93	TRW	**GLONASS-M System Description (7)**
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IWG2-52 = 1-60	3/3/93	J. Wengryniuk, Comsat	**Status Report to IWG1 from IWG2 Drafting Group A on MSS/RDSS Sharing with Radio Astronomy (3)**
IWG2-53 = 1-61	3/4/93	S. Nguyen, Comsat	**Second Status Report of IWG2/Drafting Group 2B to IWG1 on MSS/Aeronautical Radionavigation Service Sharing (1)**
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IWG2-55	3/4/93	W. Vivian, Vivian Assoc for Wireless Cable Assn	**MMDS/ITFS/OFS emissions into adjacent MSS 2483.5-2500 MHz band (1)**
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IWG2-61 (Rev. 4)	3/30/93	J. Wengryniuk, Comsat Labs, Chmn DG2A	**Final revision of technical report of DG2A**
IWG2-61a	3/5/93	R. Gould, Telecommunications Systems	**Comments and Proposed Changes to §§5.1.2, 5.2.1, and 5.2.2 of Doc 61 (12)**

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IWG2-64	3/11/93	P. Malet & A. Mamlet, Steptoe et al. for Motorola	Highlights of the Sixth Meeting of IWG2 (3/5/93) (9)
IWG2-65 (= 1-65)	3/11/93	J. Wengryniuk, Chair-man DG2A	Status Report of Drafting Group 2A to IWG1
IWG2-66	3/11/93	AMSC	Interference from ISM in the United States (A collection of filings on ISM use of the 2400-2500 MHz band in Docket 89-554) (40)
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IWG2-61 (Rev. 2) (MSSAC 42.4)	3/17/93	J. Wengryniuk, Comsat, Chmn DG2A	Second revision of technical report of DG2A
IWG2-67 (MSSAC 42.2)	3/9/93	E. Reinhart	Second report of Working Group 2 to the MSS above 1 GHz Negotiated Rulemaking Committee (1)
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IWG2-70	3/15/93	J. Knudsen, Motorola	Interference power due to ISM emitters in the 2483.5-2500 MHz band (10)
IWG2-71	1/92	NTIA	"Accommodation of Broadcast[ing-] Satellite (Sound) and Mobile Satellite Services in the 2300-2450 MHz Band" - NTIA Technical Memorandum 92-154 (46)
IWG2-72	3/11/93	LQSS	Sharing with Glonass
IWG2-73	3/23/93	S. Clark, Motorola	Summary of Informal Working Group 2 meeting of March 15, 1993
IWG2-74 (Rev. 3) (MSSAC 42.5)	3/30/93	S. Nguyen, Comsat, Chmn DG2B	Final revision of technical report of DG2B

IWG2-75 (Rev. 4) (MSSAC 42.6)	4/2/93	W. Pritchard for LQSS & R. Weiblen for CELSAT, Chmn DG2C	Final revision of technical report of DG2C
IWG2-76		R. Erlandson, Rockwell	An analysis of protection zones for MSS uplink/Glonass frequency sharing during en-route navigation (4)
IWG2-77	3/24/93	P. Rodriguez for TRW	Analysis of ISM interference in the band 2483.5-2500 MHz (35)
IWG2-78 (MSSAC 42.3)	3/25/93	E. Reinhart, Coordinator IWG2	Third Report of IWG2 to the MSS above 1 GHz NRC (1)
IWG2-79	3/25/93	S. Clark, Motorola	Summary of Eighth Meeting of IWG2 on 3/23/93 (2)
IWG2-80 (Rev. 4)	4/6/93	E. Reinhart, Coordinator IWG2	Report of Informal Working Group 2 (Inter-service Sharing) to the MSS Above 1 GHz Negotiated Rulemaking Committee
IWG2-81	3/30/93	S. Clark, Motorola	Summary of Geostar RDSS Interference Report for ISM Type Emissions
IWG2-82	4/2/93	S. Clark, Motorola	Summary of Ninth Meeting of IWG 2 on 3/30/93 (2)

Attachment A
to MSSAC-42.7 (Rev. 5)

(also numbered as Doc. IWG2-61 (Rev.4) and MSSAC-42.4)

Informal Working Group 2

Technical Report on MSS/RDSS Sharing With Radio Astronomy Service in the Bands 1,610 to 1,626.5 MHz and 2,483.5 to 2,500 MHz

Prepared by
Drafting Group A of
Informal Working Group 2

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Section 1
Background

1.1 Nature of Radio Astronomy

A substantial portion of what has been learned about the Universe in the last 60 years is based on the study of the radio region of the electromagnetic spectrum. Most cosmic radio emissions are similar to random noise in nature and have extremely low power flux levels at the Earth. Broadly speaking, they can be classified into continuum and line radiation.

The intensity of continuum radiation varies smoothly with frequency, often over several decades of frequency. To determine the nature of continuum spectra, astronomers need to observe them at several frequencies, but the exact frequency of these measurements is unimportant.

Line radiation occurs when an atom or molecule loses a discrete amount of energy. This radiation has a specific frequency and, thus, results in a "line" in the radio spectrum. Each type of atom or molecule is characterized by a set of lines which yields specific information and must be observed at these frequencies. Spectral lines in astrophysical sources are often broadened by turbulent motions, or appear Doppler shifted due to systematic motions. In our galaxy, systematic motions of up to ±300 km/s occur. Because of the general expansion of the Universe, sources in other galaxies may appear redshifted by thousands, or even tens of thousands of km/s.

Astrochemistry is a relatively new and very exciting branch of astronomy which studies the formation and abundance of molecules in the Universe. The OH (hydroxyl) radical was the first molecule to be detected at radio frequencies in interstellar space in 1963. It has four lines, which occur at approximately 1,612, 1,665, 1,667, and 1,720 MHz, all of which have been observed in our own galaxy, as well as in external galaxies.

Astronomers have discovered that the conditions for Microwave Amplification by Stimulated Emission of Radiation (MASER) of OH lines often exist around young stars and that these powerful narrowband signals provide a readily detectable signature of star formation. Thus, the study of OH lines is of great interest for investigations of the initial stages of the evolution of stars and the formation of protostars. Very Long Baseline Interferometry (VLBI) observations of OH maser sources have shown that these sources have angular sizes of 0.01 arcseconds and less. Such high-resolution observations allow radio astronomers to investigate the heart of star-forming regions.

To interpret most observations of the hydroxyl line radiation in terms of physical conditions, it is necessary to measure the relative strength of several lines. Loss of a single line from the data set can impede and even prevent study of broad classes of physical phenomena. In addition, in certain stages of their evolution, some classes of stars may radiate only one of the lines. Thus, the 1,612-MHz line is the dominant one for naturally occurring masers around infrared stars. The study of the OH emission at 1,612 MHz allows astronomers to gauge such physical properties of the stars as the rate at which gas is blown off and recycled into the interstellar medium. The characteristics of the surrounding gas shells which can be measured include their size, density, and rate of expansion. Some of these characteristics cannot be inferred from any other astronomical observations. Further, measurements of some of these characteristics in OH emitting stars in the central region of our galaxy have been used to estimate the distance to the galactic center, as well as the mass of the central bulge of the galaxy.

In contrast, the OH component of interstellar clouds, which is not associated with stars, may emit most strongly in the 1,665- and 1,667-MHz lines. The OH molecule is also used to study the spatial distribution of the molecular component in our galaxy and in external galaxies. Finally, extremely strong maser emission has been detected near the nuclei of a number of external galaxies. This OH megamaser emission from galactic nuclei can be more than a million times more luminous than maser emission in our galaxy and can be observed to great distances. Use of these very peculiar and active galaxies allows astronomers to study the temperature and density of the molecular gas in the center of these galaxies.

A list of currently existing U.S. radio observatories equipped to observe the OH lines is given in Section 3. A list of foreign radio telescopes known to observe in the band is also given in that section.

1.2 Regulatory Protection

CCIR Recommendation 314-7 lists the 1,612.231-MHz line of the OH radical among the radio frequency lines of greatest importance to radio astronomy below 275 GHz. Rec 314-7 suggests the 1,606.8- to 1,613.8-MHz range as the minimum band to be protected for radio astronomy observations. The upper edge of the minimum suggested bandwidth (1,613.8 MHz) reflects the highest blueshifts that occur in our galaxy, corresponding to velocities of 300 km/s, 1,613.8 MHz is, consequently, the highest frequency at which observations of the 1,612-MHz line are of astronomical interest. The lower edge (1,606.8 MHz) of the minimum band corresponds to redshifted velocities of 1,000 km/s, found approximately at the distance of the Virgo Cluster of galaxies. Much higher astronomical redshifts exist (up to about 50,000 km/s corresponding to frequencies of about 1,340 MHz), and are of great interest to astronomers. These highly redshifted objects are observed as opportunity permits. WARC-92 allocated the 1,610.6- to 1,613.8-MHz band to the radio astronomy service on a worldwide, primary, shared basis. The width of this allocation reflects the ±300-km/s velocity range, observed to occur in our galaxy.

The following international footnotes and regulations apply to sharing with radio astronomy:

> RR 343 states: "The frequency assigned to a station of a given service shall be separated from the limits of the bands allocated to this service in such a way that, taking account of the frequency band assigned to a station, no harmful interference is caused to services to which the frequency bands immediately adjoining are allocated."

RR 344 states: "For the purposes of resolving cases of harmful interference, the radio astronomy service shall be treated as a radio communication service. However, protection from services in other bands shall be afforded the radio astronomy service only to the extent that such services are protected from each other."

RR 733E: Harmful interference shall not be caused to stations of the radio astronomy service in the band 1,610.6 to 1,613.8 MHz by stations of the radio determination satellite and mobile satellite services (No. 2904 applies).

Note that RR 733E applies to terrestrial, aircraft, or space stations, operating in the Earth-to-space or space-to-Earth direction at any frequency within the 1,610- to 1,626.5-MHz band and is not limited to the 1,610.6- to 1,613.8-MHz portion of the band.

RR 734: In making assignments to stations of other services, administrations are urged to take all practicable steps to protect the radio astronomy service in the band 1,610.6 to 1,613.8 MHz from harmful interference. Emissions from space or air-borne stations can be particularly serious sources of interference to the radio astronomy service (see Nos. 343 and 344 and Article 36).

RR 2904 (Art 36) states: "Administrations shall take note of the relevant CCIR recommendations with the aim of limiting interference to the radio astronomy service from other services."

Article 36 of the Radio Regulations (RR 2892-2904) discusses the Radio Astronomy Service (RAS) in terms of general provisions, the measures to be taken by radio astronomy stations to reduce their susceptibility to interference, and the protection afforded to the RAS by Administrations.

CCIR Recommendation 224-7 discusses harmful interference limits for the RAS.

Section 2
Existing and Future Potential Interference to Radio Astronomy

2.1 Present Interference From GLONASS

Radio astronomy observations in the 1,610.6- to 1,613.8-MHz band do suffer heavy interference from transmissions of the Russian GLONASS system, at present. In fact, narrow spikes due to GLONASS transmissions have been detected even in the 1,660.5- to 1,670-MHz passive band. It is observed that radio astronomy observations have been interfered by GLONASS in the 1,610.6- to 1,613.8-MHz band and that less than 10 percent of the measured spectra were usable when GLONASS operated normally. No observations will be possible if the system is completed as currently planned.

During the last 2 years radio astronomers, represented by the Inter Union Commission on Allocation of Frequencies (IUCAF), met several times with the GLONASS administration, and with other Russian organizations responsible for the system, to discuss possible ways of sharing the 1,610.6- to 1,613.8-MHz band. As a first step toward resolving the problem, tests were conducted at a number of observatories around the world on November 21 and 22, 1992, in collaboration with the GLONASS Administration. As a result, it was determined that radio astronomy observations are possible most of the time when there are no GLONASS transmissions directly in the band of interest to radio astronomy.

The radio astronomy community will continue discussing possible ways to redesign the GLONASS system to achieve the objective of reducing interference to radio astronomy. The next meeting is scheduled to be held in the middle of April 1993 in Moscow.

It should be noted that some of the potential solutions to the GLONASS interference to radio astronomy problem may also ameliorate MSS/GLONASS interference problems. In taking steps to resolve the problems for radio astronomers, it is therefore desirable to seek solution that also solve MSS/GLONASS interference problems. Examples of such approaches are identified in [report of IWG2 Drafting Group B].

2.2 Potential Future Interference

Transmissions from MSS systems could interfere with radio astronomy receivers in four ways, as follows:

1. Transmissions from terrestrial mobile terminals (MESs) using the 1,610.6- to 1,613.8-MHz band for uplinks could interfere with receivers at nearby radio astronomy observatories making measurements of faint signals in the same band. Out-of-band emissions from MES transmissions in the bands 1,610 to 1,610.6 and 1,613.8 to 1,626.5 MHz could also interfere with radio astronomy.
2. Out-of-band transmissions from MSS satellites using the 1,613.8- to 1,626.5-MHz band for downlinks could interfere with receivers at radio astronomy observatories making measurements in the adjacent 1,610.6- to 1,613.8-MHz band.
3. Spurious, second harmonics of the MSS downlink transmissions in the band 2,483.5 to 2,500 MHz could interfere with radio astronomy receivers in the band 4,990 to 5,000 MHz.
4. MSS Intersatellite Links (ISLs) in the band 22.5 to 23.0 GHz. Emissions from these bands could interfere with radio astronomy sites observing in the bands 22.81 to 22.86 GHz and 23.07 to 23.12 GHz.

Of the four interference mechanisms listed above only the first three will be addressed in this report. Interference from MSS ISL's will be addressed by MSAC IWG3. As will be shown in Section 5 of this report, there are practical ways to control all of these interference modes without seriously affecting the performance, capacity or cost of MSS and RDSS systems.

2.3 Required PFD Limits to Protect Radio Astronomy

CCIR Report 224 specifies the recommended protection limits for the RAS. In the 1610.6- to 1613.8-MHz band the limit is –238 dB(W/m^{2}Hz). The limit for the 4,990- to 5,000-MHz band is –241 dB(W/m^{2}Hz). Throughout the remainder of this report interference levels exceeding these limts shall be referred to as "unacceptable" interference.

Note that all observatories currently operating in the United States, and those that may come into operation in the future, will make only spectral line measurements in the 1,610.6- to 1,613.8-MHz band, and only continuum measurements in the 4,990- to 5,000-MHz band. Therefore, only the limit from CCIR Report 224 appropriate for each type of observation need be considered. It should also be noted that VLBA sites in the U.S. are less sensitive to interference and therefore require less protection.

Section 3

Radio Astronomy Sites to Be Protected

Table 3-1 lists U.S. radio astronomy sites to be protected in the 1,610.6- to 1,613.8-MHz band. The list is believed to be comprehensive at the present time. It is unlikely, but not impossible, that other sites will be added to the list within the next 5 to 10 years.

Table 3-2 lists non-U.S. radio astronomy sites to be protected in the 1,610.6- to 1,613.8-MHz band. Some observatories in the former Soviet Union may also make observations in this band, but geographical data on these sites was not available. The list is believed to be complete, but some sites may have been overlooked. It is unlikely, but not impossible, that new sites will be added to the list within the next 5 to 10 years.

Complete data for all the sites were not available. When available, the height indicated is that of the feed above mean sea level. These sites are indicated with an asterisk. Heights given for the other telescopes are either those of the site or of the feed, depending on data available, and should be considered lower limits.

Table 3-1. U.S. Radio Astronomy Observatories Observing in the 1,610.6- to 1,613.8-MHz Band

TELESCOPE	LATITUDE (O ' ")	LONGITUDE (O ' ")	HEIGHT (m AMSL)[5]
Arecibo (NAIC)[1]	18 20 46	66 45 11	402
Green Bank Telescope (NRAO)[2]	38 25 59	79 50 24	946
42.7 m (NRAO)[2]	38 26 08	79 49 42	825
VLA (NRAO)[3]	34 04 43	107 37 04	2,155
VLBA (NRAO)[4]			
Pie Town, NM	34 18 04	108 07 07	2,402
Los Alamos, NM	35 46 30	106 14 42	1,946
Kitt Peak, AZ	31 57 22	111 36 42	1,946
Ft. Davis, TX	30 38 06	103 56 39	1,645
N. Liberty, IA	41 46 17	91 34 26	271
Brewster, WA	48 07 53	119 40 55	285
Owens Va, CA	37 13 54	118 16 34	1,237
St. Croix, VI	17 45 31	64 35 03	46
Mauna Kea, HI	19 48 16	155 27 29	3,749
Hancock, NH	42 56 01	71 59 12	339
Owens Valley Radio Obs.	37 13 54	118 17 36	1,237
Ohio State Univ. Obs.	40 15 06	83 02 54	310

[1]The Arecibo Telescope, Arecibo, PR, of the National Astronomy and Ionosphere Center (NAIC), is operated by Cornell University, under a cooperative agreement with the National Science Foundation (NSF).

[2]The Green Bank Telescope (GBT) of the National Radio Astronomy Observatory (NRAO), under construction at Green Bank, WV, will be completed in 1995. NRAO is operated by Associated Universities, Inc., under a cooperative agreement with NSF. For the purposes of a protection zone, the radius of this zone will be centered on the coordinates of the Green Bank Telescope.

[3]The Very Large Array (VLA) of the NRAO consists of 27 telescopes, arranged in a Y shape, located on the Plains of San Augustin, NM.

[4]The Very Long Baseline Array (VLBA) of the NRAO consists of ten dishes located throughout the continental U.S., Hawaii, and the U.S. Virgin Islands. Tapes recorded separately at each site are correlated in a specially built digital correlator, to construct images with an angular resolution better than one thousandth of an arc second.

[5]In all cases the height of the feed above mean sea level is given.

Table 3-2. Non-U.S. Radio Telescopes Equipped to Observe in the 1,610.6- to 1,613.8-MHz Band

TELESCOPE	LATITUDE (O ' ")	LONGITUDE (O ' ")	HEIGHT (m AMSL)[5]
Argentina Instituto Argentino de Radioastronomia	S 34 52 06	W 58 08 12	11
Australia			
Australia National Radio Astronomy Observatory	S 32 60 00	E 148 15 44	452*
Australia Telescope Compact Array			
Mt. Pleasant Radio Obs	S 42 48 18	E 147 26 21	70*
Canada			
Dominion Radio Astrophysical Obs.	N 49 19 12	W 119 37 12	556*
India			
Giant Meterwave Radio Telescope	N 19 05 30	W 74 03 00	700*
United Kingdom			
Nuffield Radio Asgronomy Labs	N 53 09 22		
Darnhall	N 53 09 22	W 02 32 03	47
Defford	N 52 06 01	W 02 08 35	
Knockin	N 52 47 24	W 02 59 45	66
Jodrell Bank	N 53 14 11	W 02 18 26	169*
Jodrell Bank	N 53 14 01	W 02 18 09	
Jodrell Bank	N 53 06 45	W 02 35 46	
Pickmere	N 53 17 18	W 02 26 38	35
France			
Nancay Obs.	N 47 23 00	E 02 12 00	130
Sweden			
Onsala Obs.	N 57 23 47	E 11 55 39	39*
Germany			
Effelsberg Obs.	N 50 50 00	E 06 31 32	316
The Netherlands			
Westerbork Synthesis Radio Telescope	N 52 55 01	W 06 35 25	36*

*Complete data not available.

Section 4

Relevant Characteristics of MSS/RDSS Systems

In the determination of potential interference levels and exclusion zones for radio astronomy, certain transmission characteristics of the MSS/RDSS systems must be specified. The following paragraphs provide the relevant MSS system transmission characteristics of the uplinks and downlinks used in communicating with the user MES (mobile earth station). These characteristics may be used in developing the frequency band sharing criteria and operational requirements between each MSS system and radio astronomy. Many of the characteristics used in the following paragraphs were obtained from tables of system parameters from the Ad Hoc Committee of IWG1 that were available at the time this report was developed. Some of the relevant MSS characteristics may not be developed and/or finalized until after the complete rules for frequency band sharing have been adopted, and in those cases the final values summarized in the tables of the report of IWG1, where they exist, should be applied.

4.1 Uplink Parameters

The concern here is to protect radio astronomy sites from interference in the 1,610.6- to 1,613.8-MHz band due to MES transmissions in the 1,610- to 1,626.5-MHz band. Relevant MES transmission characteristics are listed in Table 4-1 for each of the proposed MSS system as currently contemplated. A description of each characteristic follows:

Frequency Band: The uplink frequency band may occupy all or part of the 1,610- to 1,626.5-MHz band.

MES EIRP: The EIRP of the MES to be used in determining interference levels for co-frequency use. It must be noted as to whether this value is peak, average, etc.

Channel Bandwidth: Shall contain approximately 99 percent of the mean power of the transmission.

MES EIRP Density: Equals the MES EIRP in dBW - 10 Log (Channel bandwidth in Hz).

MES User Density per Beam: User density within an uplink beam which can be used to calculate user geographical density.

MES Out-of-Band Emissions: Includes spurious emissions which might occur in the 1,610.6- to 1,613.8-MHz band when the MES primary transmission is outside this band, but still within the 1,610- to 1,626.5-MHz band. This is essentially a transmission mask and would provide limits of all undesirable emissions in units of dBW/Hz as a function of frequency offset from the transmission center frequency. This characteristic would be used to assess adjacent bandwidth (or channel) interference levels.

Other Pertinent Characteristics: Any other required relevant parameters (e.g., detailed frequency plans). May not be needed for every system.

4.2 Downlink Parameters

The concern here is twofold: 1) to protect radio astronomy sites from interference in the 1,610.6- to 1,613.8-MHz band due to out-of-band MSS satellite transmissions in the 1,613.8- to 1,626.5-MHz band, and 2) to protect radio astronomy sites from interference in the 4,990- to 5,000-MHz band due to the second harmonics of MSS satellite transmissions in the 2,483.5- to 2,500-MHz band. Relevant satellite transmission characteristics are listed in Tables 4-2 and 4-3 for these two concerns, respectively, for each applicable MSS system as currently contemplated. A description of each characteristic follows:

Frequency Band: The downlink frequency band may occupy all or part of the 1,613.8 to 1,626.5 MHz band for Table 4-2 or the 2,483.5 to 2,500 MHz band for Table 4-3.

Operating PFD: Maximum spectral power flux density (PFD) on the surface of the Earth from each MSS system defined in both 4 kHz and 1 Hz bandwidths (Note: Assumed that the spectrum is flat over the 4 kHz). This provides a basis for determining the amount of rejection required within the satellite when comparing the interfering PFD level (as stated in the next row) with the operating PFD level of the desired satellite transmission.

Anticipated Maximum PFD From Each MSS in the 1,610.6- to 1,613.8-MHz Band for Table 4-2 (or the 4,990- to 5,000-MHz Band for Table 4-3): Used to develop estimate of interference level.

Other Pertinent Characteristics: Any other required relevant parameters (e.g., detailed frequency plans) may not be needed for every system.

Table 4-1. Relevant User-to-Satellite Uplink Characteristics of MSS/RDSS Systems in the 1,610.6- to 1,613.8-MHz Band from MES Terminal Emissions in the 1,610- to 1,626.5-MHz Band

ITEM	UNITS	AIRES	AMSC	CELSTAR	ELLIPSO
Frequency Band	MHz	1,610 to 1,626.5	1,610 to 1,626.5	1,610 (?)	1,610 to 1,626.5
MES EIRP	dBW	0.6	4.0[1]	-9.0	4.0
Channel Bandwidth	kHz	1,000 to 5,000	5,500	1,250	1,100
MES EIRP Density	dBW/Hz	-56.2 to -63.2	-63.4	-70.0	-56.4
MES User Density per Beam	Users/mi²	TBD	TBD	TBD	TBD
MES Out-of-Band Emissions in the 1,610.6- to 1,613.8-MHz Band		Applicant to describe	2	Applicant to describe	Applicant to describe
Other Pertinent Characteristics		Applicant to describe	3	Applicant to describe	Applicant to describe

ITEM	UNITS	ELLIPSO II	GLOBALSTAR	IRIDIUM	ODYSSEY
Frequency Band	MHz	1,610 to 1,626.5	1,610 to 1,626.5	1,616 to 1,626.5	1,610 to 1,626.5
MES EIRP	dBW	11.0	-4.0	-9.0 to 6.0	-1.0 to 9.0
Channel Bandwidth	kHz	1,400	1,250	31.5	4,833
MES EIRP Density	dBW/Hz	-50.5	-65.0	-54.0	-67.8
MES User Density per Beam	Users/mi²	TBD	TBD	TBD	TBD
MES Out-of-Band Emissions in the 1,610.6- to 1,613.8-MHz Band	dBW/Hz	Applicant to describe	Applicant to describe	-130 Avg over 20 mS	Applicant to describe
Other Pertinent Characteristics		Applicant to describe	Applicant to describe	Applicant to describe	Applicant to describe

Note: All values subject to change.

[1] Average toward horizon.

[2] As required for protection of GLONASS (per DG2B).

[3] The above parameters are for vehicular MES operating through geostationary satellites. AMSC contemplates alternative narrowband uplinks that operate above 1,616.5 MHz and would meet the above out-of-band emission limit. AMSC also plans to serve handheld MES via a later generation space segment with EIRP levels toward the horizon that are substantially less than -3 dBW.

[4] Average density for peak loading conditions.

Table 4-2. Relevant Satellite-to-User Downlink Characteristics of MSS/RDSS Systems in the 1,610.6- to 1,613.8-MHz Band from Out-of-Band Emissions Due to Satellite Emissions in the 1,613.8- to 1,626.5-MHz Band

TEM	UNITS	IRIDIUM
Frequency Band	MHz	1,616 to 1,626.5
Operating PFD on Earth	$dBW/m^2/4\,kHz$ $dBW/m^2/Hz$	−126.8 −162.8
Anticipated Maximum PFD in the 1,610.6- to 1,613.8-MHz Band From Each MSS	$dBW/m^2/Hz$	TBD
Other Pertinent Characteristics		Applicant to describe

Note: All values subject to change.

TBD = To Be Determined.

Table 4-3. Relevant Satellite-to-User Downlink Characteristics of MSS/RDSS Systems in the 4,990- to 4,000-MHz Band from Spurious Emissions Due to Satellite Emissions in the 2,483.5- to 2,500-MHz Band

ITEM	UNITS	AIRES	AMSC	CELSTAR	ELLIPSO
Frequency Band	MHz	2,483.5 to 2,500	2493.6 to 2499.2	?	2,483.5 to 2,500
Operating PFD on Earth	dBW/m^2/ 4 kHz	TBD	–139.0[1]	–142.0	–142.0
	dBW/m^2/ Hz	TBD	–175.0[1]	–178.0	–178.0
Anticipated Maximum PFD in the 4,990- to 5,000-MHz Band From Each MSS:	dBW/m^2/ Hz	TBD	–240.0	TBD	TBD
Other Pertinent Characteristics		Applicant to describe	GEO Satellites 62° & 39°WL	Applicant to describe	Applicant to describe

ITEM	UNITS	ELLIPSO II	GLOBALSTAR	ODYSSEY
Frequency Band	MHz	2,483.5 to 2,500	2,483.5 to 2,500	2,483.5 to 2,500
Operating PFD on Earth	dBW/m^2/ 4 kHz	TBD	–142.0	TBD
	dBW/m^2/Hz	TBD	–178.0	TBD
Anticipated Maximum PFD in the 4,990- to 5,000-MHz Band From Each MSS:	dBW/m^2/Hz	TBD	≤241	TBD
Other Pertinent Characteristics		Applicant to describe	Applicant to describe	Applicant to describe

Note: All values subject to change.
[1]At peak loading.
TBD = To Be Determined

Section 5
Approaches to Protecting the Radio Astronomy Service

As discussed in Subsection 2.1 of this report, because of interference from the GLONASS system, up to 90 percent of radio astronomy observations of the 1,612-MHz line are lost. Thus, the time spent observing this line is relatively small at present. According to radio astronomers, scientific interest in 1,612-MHz observations remains high, however, and if GLONASS interference in this band is reduced observations at 1,612 MHz are likely to increase substantially. While it is impossible to predict the fraction of time that U.S. radio telescopes expect to dedicate to 1,612-MHz observations, it is reasonable to assume that they will not exceed 25 percent. It should be noted that radio astronomy sites need to be protected from MSS/RDSS transmissions in the 1.6-GHz band only when the sites are observing in this band.

Scheduling of telescopes takes place usually at least a month in advance. The radio astronomy community is willing to establish a notification procedure of observations in the 1,612-MHz band within the U.S. through the Electromagnetic Spectrum Management Unit, National Science Foundation, Washington, D.C. 20550. This procedure could result in a database readily accessible by MSS/RDSS system operators, thereby providing these operators with the times during which radio astronomy sites need to be protected.

There are a number of techniques available to prevent unacceptable interference from MSS/RDSS systems into radio astronomy. With respect to the MSS/RDSS 1,610- to 1,626.5-MHz earth-to-space transmissions, mobile terminals can be prohibited from transmitting in the 1,610.6- to 1,613.8-MHz RAS band in the vicinity of radio astronomy sites. It should be noted that MSS/RDSS terminals onboard aircraft could cause interference to radio astronomy sites at distances much greater than those associated with land-based terminals.

Interference to radio astronomy observatories from downlink MSS transmissions in the band 1,613.8 to 1,626.5 MHz, to which MSS is allocated on a secondary basis, can be controlled through a combination of sharp skirted filters in the MSS satellite and leaving a modest guard band just above 1,613.8 MHz, the upper limit of the radio astronomy band.

Sharp skirted filters in the MSS satellite can also reduce second harmonics from the 2,483.5- to 2,500-MHz MSS space-to-earth allocation from causing harmful interference to radio astronomy in the 4,990- to 5,000-MHz radio astronomy band.

As noted above, restrictions on mobile terminals would only apply to terminals in the vicinity of an observatory actively making measurements, however interference